

UNIVERSITY OF CALIFORNIA INSTITUTE OF MARINE RESOURCES

THE SCRIPPS INSTITUTION OF OCEANOGRAPHY MARINE TECHNICIANS HANDBOOK:

ROCK DREDGING IN DEEP-SEA AREAS

Robert L. Fisher and Paul J. Liebertz

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MARINE TECHNICIAN'S HANDBOOK

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GENERAL INTRODUCTION

This publication is one of a series intended to provide explicit instructions for the collection of oceanographic data and samples at sea. Individual chapters are being issued separately so that they may be made available as they are prepared and may be replaced by updated versions without replacing the entire series. It can, therefore, be considered as an open-ended "marine technician's handbook".

For many years there have been such manuals in existence within various groups at the Scripps Institution of Oceanography for internal use. These manuals are being updated, and new ones are being prepared where no satisfactory ones existed; they will be issued as they are ready.

The instructions on physical, biological, and chemical oceanographic data collection and processing have been prepared by members of the Data Collection and Processing Group (DCPG), part of the Marine Life Research Group of Scripps. They cover procedures used by that group. Other chapters on geological and geophysical techniques are based on the "Marine Technician's Handbook" series originally prepared by Mr. Frederick S. Dixon, and issued by the Oceanic Research Division some years ago. It is expected that chapters on techniques used by other groups within Scripps will be added.

Since the sections will be published individually, there will undoubtedly be some repetition. This should not detract from the overall purpose of the manual, since it is expected that a single section will be the only one needed for a particular operation. We do not wish to suggest that the methods described are the only methods; we have merely attempted to describe the methods and procedures which we use and which we have found to be reliable and up-to-date. As new information becomes available, attempts are made to test techniques, incorporate them into routine procedures, and then revise the chapter concerned.

In the final analysis the reliability and quality of the data obtained is in your hands. It is imperative that meticulous attention be given to details to insure reliability and usefulness in the results you obtain.

While we have attempted to be thorough in descriptions of techniques, this cannot be considered to be a complete "cookbook" for the novice. It is in most cases assumed that the reader has some prior knowledge and training in the field concerned. We hope, however, that these instructions can serve as a training aid for the novice marine technician, a "cookbook" for the scientist who is taking his own observations, and a reference manual for the experienced technician.

Preparation of these chapters over the years has been supported by the University of California and by grants and contracts from the many federal agencies to the Scripps Institution of Oceanography and to the Institute of Marine Resources. Support for preparation of this more complete and revised manual has come from the National Sea Grant Program.

Dr. Robert L. Fisher of the Geological Research Division of Scripps has had the primary responsibility for this chapter on deep-sea rock dredging. He has incorporated material written by Paul J. Liebertz. Additional aid and advice were contributed by Jeffrey D. Frautschy, Robert M. Beer, and James L. Coatsworth.

G. G. Shor, Jr.
Sea Grant Program Manager

Rock Dredging in Deep-Sea Areas
February 17, 1973

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ROCK DREDGING IN DEEP-SEA AREAS

GENERAL STATEMENTS

The aim of geological dredging is to recover well-located samples of coherent material, for example igneous rock or coralline debris, from the sea floor. As in the case of the geologist sampling outcrops at discrete points areally or up a section, position - both absolute and relative to other samples - is extremely important. In this regard, effort expended in determining or estimating the probable direction of drift and then in positioning the ship accordingly, ordinarily up drift from an unslope, is time well-spent before putting a dredge overside. Ideally, dredging is done with the ship drifting. Very often, however, the ship must be moved, as slowly as possible, into the seas, weather or currents in order to haul the dredge upslope or in the desired direction or area.

Full dredge hauls can be obtained as often by drifting as by using the engines to tow the dredge across the bottom. Furthermore, with the more localized collecting profile of a short drift traverse, the sample assemblage is not so mixed a bag. A large catch depends on size and abundance of loose or breakable hard material, on "angle of attack" of the dredge lip, on keeping the dredge on bottom, and on other factors; it is not solely a result of dragging over a long track. For that matter, four or five gunny sacks of a uniform fresh basalt are perfectly adequate for chemical and petrographic investigations, for the reference collections, and for distribution to other laboratories. Thirty or so bags, as yielded by a nearly full chain-bag dredge, are not required.

Assuming that weather and sea conditions, sea floor configuration, and locality intended for sampling permit a choice of whether to dredge while under power or while drifting, there may be specific advantages to the latter method:

- 1) Drifting provides continuity of position and an indication of current velocity.
- 2) Drifting gives a rather precise position of a short stretch of sampled bottom. (This is ordinarily offset laterally from the ship; "overage" of wire out, with respect to bottom depth and steepness, gives an indication of this offset.)

- 3) Drifting affords adequate tension to break off fresh hard rock, receiving plenty of help from the heave of a ship as large as the Scripps research vessels, THOMAS WASHINGTON or MELVILLE*. In this connection, volcanic flows are cracked and fragmented, as are pillows of basalt, so that fresh material often can be plucked or broken off with only 2000-3000 lbs. over static weight. Commonly, much greater tensions appear when the dredge hangs up on old, thoroughly-cemented coralline deposits or - very rarely indeed - on unjointed outcrops.
- 4) Drifting largely eliminates sudden increases in wire tension, although with the wire presently used on Scripps ships such jumps are not alarming. Build-ups are slower and better-controlled, and may be regulated by hauling in, stopping, or paying out the wire. If the engine room approves, one can keep an engine standing by in case of the need to maneuver to free a dredge. However, if a hang-up occurs while drifting, it is possible to remain there, with a high but safe tensiometer reading, paying out little or no wire, until a shut-down engine can be warmed up and put back into operation.
- 5) When the tension surges resulting from the ship's (powered) actions are eliminated, the tensiometer record gives some clue as to the nature of the bottom.
- 6) Lastly, if the ship is not under power and the dredge is not yet free of the bottom, the dredge often anchors the ship. Thus, as wire is retrieved, the vessel is pulled backward toward the sample's position. (On vessels such as ARGO and THOMAS WASHINGTON this technique could be applied even in rather rough weather. MELVILLE'S differently-configured stern and ramp make such backing inadvisable except in calm seas.) Satellite fixes may be obtainable during the movement backward, and the dredge commonly is freed by hauling vertically, or nearly so. Length of the near-vertical wire at lift-off gives a fair measure of the maximum final sampling depth (on steepish slopes the echo-sounder reads shallow).

*Approximately 210 feet, 1150 gross tons, and 245 feet, 1805 gross tons, respectively.

THE PINGER IN DREDGING

Regardless of the availability of satellite navigation and taking account of weather conditions and currents, percentage of success and knowledge of sample position are enhanced not only by detailed and meticulous note-keeping throughout the lowering, but also by placing a pinger on the dredge wire whether dredging is by drifting or under power at up to 3 knots. This is so because such a pinger is an additional sensor providing resolution near the dredge. Even in the roughest, deepest parts of the oceans, the Pacific trenches, experience and trials have established that E.G. & G. pingers are neither damaged nor are they especially risked in carefully monitored and well-documented dredging operations on our present 9/16" wire (3 x 9, torque-balanced, elevated yield strength).

Both for massive savings in station time and for establishing the sample's position, the advantages of using a pinger are plain:

- 1) A pinger lets one know if, and exactly when, the dredge encounters and leaves the bottom.
 - a) Dry (or here perhaps "wet") runs are eliminated. A dredge still may come up empty; if it does so after definitely having been on bottom for some time, the operation should not be repeated at that locality.
 - b) "Contact by consensus" and "fishing for bottom" are eliminated, as are excursions to the fantail to check the wire angle (except, of course, in coming about when the wire is near the ship or tending forward). The depth recorder provides a moment-by-moment documentation of the haul; this sonic evidence may be compared to the concomitant trace provided by the recording tensiometer. The dredge can be lowered with confidence and dispatch to contact. On recovery, it can be retrieved at maximum prudent speed just as soon as it leaves the bottom - regardless of wire angle, tension fluctuations, or "scope" (i.e., the wire out in excess of the vertical distance to the bottom). On recovery, when a pinger is not employed, hundreds of meters of wire may be retrieved at an unnecessarily dead-slow rate until the metered wire out equals the probable depth.

- 2) With a pinger used to determine bottom contact, experience under calm to moderate weather conditions has established that very little "scope" is required in deep water. Scope of only 2% to 5% is excellent if the ship is not under power. This saves time, especially in recovery. On the other hand, in deep water work, even very slow speeds of 1 to 3 knots greatly increase the wire needed to put the dredge on bottom, and thus reduce the precision of sample position, even when a pinger is employed.
- 3) Like a deep-tow vehicle, a pinger on the line effectively moves the sensing point to that level. Hence, over a flattish identifiable bottom of known or knowable depth, such as a trench's locally sedimented floor, for example, the pinger can be used to poise a dredge at a selected distance above the muddy floor (and therefore a known distance below the sea surface). The dredge thus can be made to encounter the trench wall at 50, 100, 150 m or any similar distance above the trench floor where outcrops might be expected. This provides a maximum depth of the sampled profile. The minimum depth is less precisely known although "wire out", when the dredge actually lifts off, provides a "maximum" minimum.

Spacing of the pinger above the dredge depends on one's confidence in being able to foresee and to forestall situations that risk the pinger. Dredging for igneous or metamorphic rock or lithified sediments routinely involves working on slopes, and most often on steep slopes, where the echo-sounder reading is not the applicable depth, and where the roughness that the sounder portrays may not be that where the dredge is operating. When dredging on deep trench walls, the pinger may better be placed far above the dredge (say up to 150 or 200 fms, 275 or 365 meters, respectively) to prevent its touching bottom or being scraped over local step-like cliffs. Working at ordinary abyssal depths of 3500 to 4500 meters and on moderate slopes, a separation of 100 or 150 fms (183 or 275 meters) is good, and is perfectly safe if the ship moves by drifting or at very slow speed. The pinger is never intentionally allowed to touch bottom. Should it happen, however, the operation can be continued as soon as the pinger is gently hoisted off the bottom.

TECHNIQUE

The two preceding sections point out some general principles and considerations that apply in differing degree to a variety of situations. There are various dredging techniques, each an adaptation to the immediate geologic requirement, weather conditions, time available, local configuration, background noise, or equipment on hand. The following "recipe" is merely an example, to be applied or modified as required to get rocks. In this instance, a pinger was used 200 fms (365 m) above the dredge, and the ship was drifting. The description is keyed to a very straightforward actual lowering (QUEBRADA 26-D) in which the dredge was on bottom slightly more than one hour. The QBRA 26-D annotated echo-sounder trace (from a PDR Mark V) is reproduced as Figure 1. Notes for a similar lowering, Case "A", are in the Appendix, Part I.

1. Shackle the chain-bag dredge (illustrated in Figure 3) to a large cast lead weight (using a safety chain around the weight) and place a swivel above the assembly. A weak-link (see page 11) may be employed on one chain of the bridle, but this has not been required on Scripps ships with the strong wire now used (32,000 lbs. ultimate, 85% yield strength).
2. Position the ship 1/2 to 3 hours up drift from the area to be sampled, allowing for the slowdown effect of several thousand meters of cable.
3. Put the dredge overside, either (a) heading into the weather at steerageway if it is rough, or (b) drifting with the ship headed downdrift if the sea is calm. Zero the winch and lab wire-metering counters with the dredge awash, and check that the recording tensiometer (if present) is functioning.
4. Put out 365 meters (200 fms) and clamp a pinger on the wire. Check the precision depth recorder record to make certain that the pinger is functioning. Seeing a bottom return at this time, however, is hardly to be expected since dredging is customarily carried out over rough, diffusely reflecting slopes.
5. Commence lowering as rapidly as is prudent, either coming about smartly and cutting the engines (see 3a above) or leaving them off. Keep in mind that the sinking velocity of the dredge is less than that of the cable alone. Regulate lowering speed to make the dredge encounter the bottom at the

ECHO-SOUNDER RECORDING (ONE-SECOND SWEEP) OF A DREDGING OPERATION ON THE EAST PACIFIC RISE (QBRA 26-D).
 WATER DEPTH: 2605 TO 2770 METERS. PINGER-TO-DREDGE SPACING: 365 METERS (200 FMS).

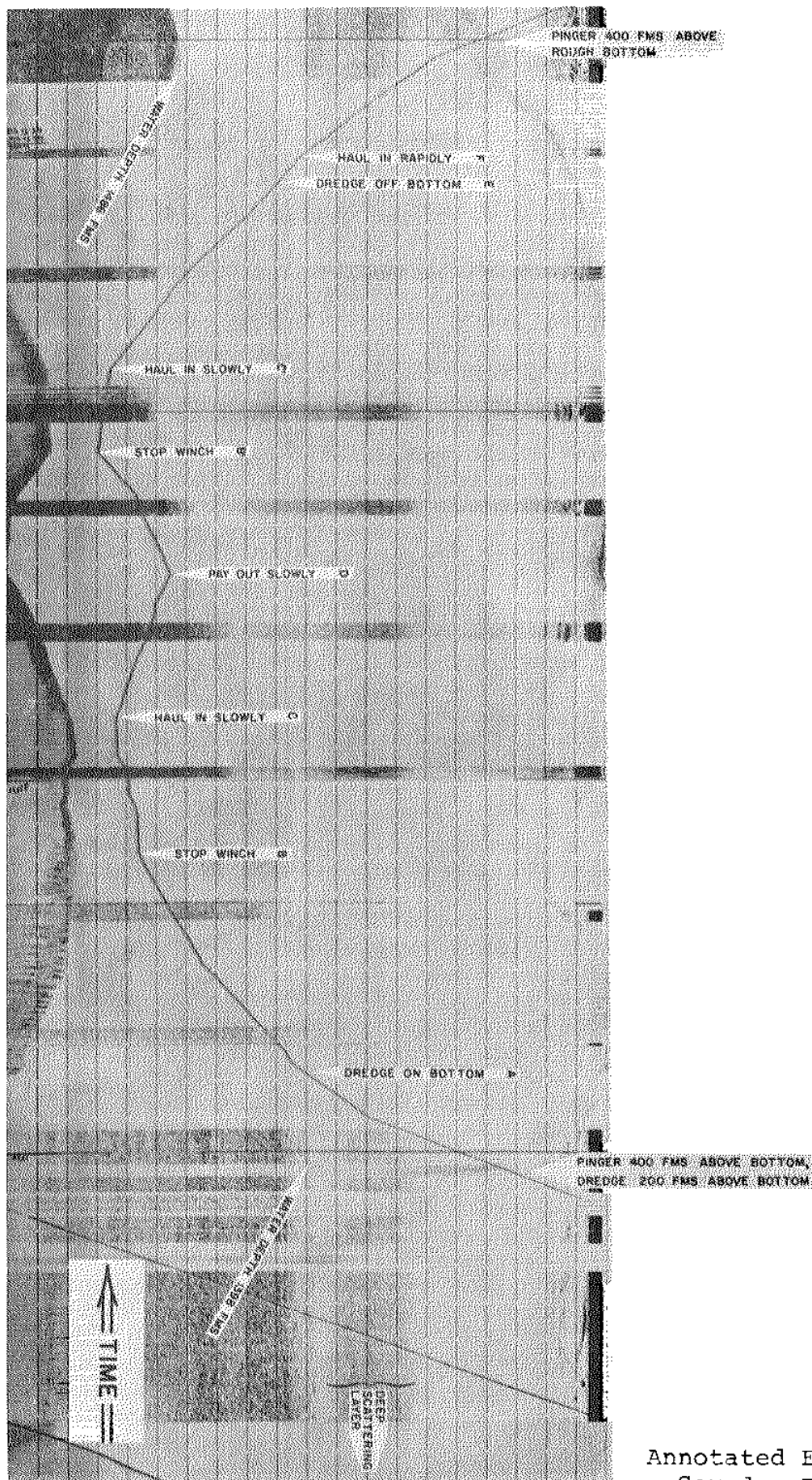


FIGURE 1

Annotated Echo
 Sounder Trace

desired spot. In this connection, one might use an engine briefly and at the lowest effective speed to make midcourse corrections. Keep watching for the appearance of a pinger bottom return, noting its relation to the wire out and the apparent water depth. As the pinger closes on the roughish bottom, the multiple or diffuse or faint "comet-tail" echoes will coalesce into a single reflection (note on opposite page, Figure 1: between A and B). So long as the direct ping is strong and dependable, there is little need to worry over "lowering blind" until the pinger nears the bottom.

6. When the pinger is 230-250 fms above the bottom (and the dredge presumably 35-55 fms above the bottom) slow the rate of paying out to 20-30 meters a minute. Note tensiometer behavior. Keep the winch operator informed of the dredge's approach to bottom; he may pick up bottom contact corroboration on his tensiometer, and later the dredge's "working" on bottom, hang-ups, and lift-off.
7. The dredge probably hits bottom when the pinger-bottom "separation" on the depth recorder is 190-195 fms (Fig. 1:A). Note the apparent water depth and the wire out; sometimes the tensiometer will deflect, giving an exact indication. At this point or slightly later, slow the pay-out rate to 5-10 m/minute, letting the ship drift away and the pinger descend to 20 to 40 fms above the bottom.
8. Stop the winch with the pinger 20-40 fms above the bottom (Fig. 1:B). As the ship drifts and the wire tautens, the pinger will rise, the "separation" will increase and the tension will go up, smoothly or in jiggling nibbles. The dredge is picking up rocks. If the drift is very slow indeed, here one might move ahead very slowly to tauten the wire and to move the dredge more rapidly. Also during this period one may pay out or haul in small amounts of wire to keep the pinger 25-50 fms above the bottom (Figure 1: between B and C), so the dredge lip will scrape the bottom in a nearly horizontal position.
9. After 10 to 30 minutes, the pinger-bottom "separation" commonly increases to 50-75 fms. The tensiometer will jiggle ("working") and occasionally stay steady at 4500-6000 lbs.

10. After a number of bites or more definite indications of increasing tension-and-relaxations on the tensiometer record have satisfied the laboratory that sufficient material has been collected, the winchman is directed to start hauling in slowly, 5-10 meters/minute (Fig. 1: C). Wire tension will increase, and so will the pinger-bottom separation. The dredge either will stay hung-up so that the ship is hauled astern, or the dredge will continue to move forward collecting rocks. With THOMAS WASHINGTON or MELVILLE, one commonly gets 3 or 4 increases to 8000 or 12,000 lbs. (and abrupt fall-offs to 2500-3000 lbs.) before the "separation" reaches 190-195 fms and the dredge comes off bottom (Fig. 1: E) - usually with one strong final deflection. Record in the notes the water depth, tension and wire out when the dredge comes off (as well as at the strong lift-offs as it comes across the bottom). In our experiences, the strongest bites occur when the "separation" is 100-125 fms.
11. If time allows and/or the bites have seemed unconvincing, and/or one is not concerned about mixing the sampling, repeat steps 7 through 10 (Fig. 1: D, et seq.).
12. With the "separation" 195-205 fms and the tensiometer steady at 3000 to 6000 lbs. (depending on the amount of water and wire out), have the winchman hoist as rapidly as he feels to be prudent (Fig. 1: F).
13. When the winch's meter counter (and/or its repeater in the laboratory) registers 1000 or so meters of wire out, men should go out on deck to watch the wire and to prepare to remove the pinger. Here, as in all wire operations, reduce the hoisting rate well before the object on the wire is expected to surface. If the seas are rough, swing the ship into the weather at low speed before removing the objects.
14. Land the dredge, easing it aboard and using steadying lines looped through the bridle to control its pendulum motion.
15. In ordinary depths (about 4000 meters) the whole operation can be expected to take 3 to 4 hours. In very deep trenches it takes 5 to 7 hours.
16. Finally, good notes are essential for later interpretations.

Variations on the sample sequence above are obvious and the geologically-aware operator soon perfects his own preferred techniques, adapting these to the situation and the equipment at hand. In all this abyssal dredging, one needs a fair to excellent knowledge of the seafloor topography, an intended profile or direction of sampling, and some basic knowledge of weather, sea and current effects, and of the ship's behavior in response to these effects. One point to keep in mind, and one that is especially useful when dredging without a pinger: under slight to moderate weather conditions while dredging at abyssal depths, "scope" need not be great - perhaps 2% to 10% over the vertical distance to the bottom - if the ship is drifting or is powered extremely slowly.

With another technique, sometimes called "power dredging" (see Figure 2, below), the vessel uses the power and steering necessary to remain stationary above or nearly above the

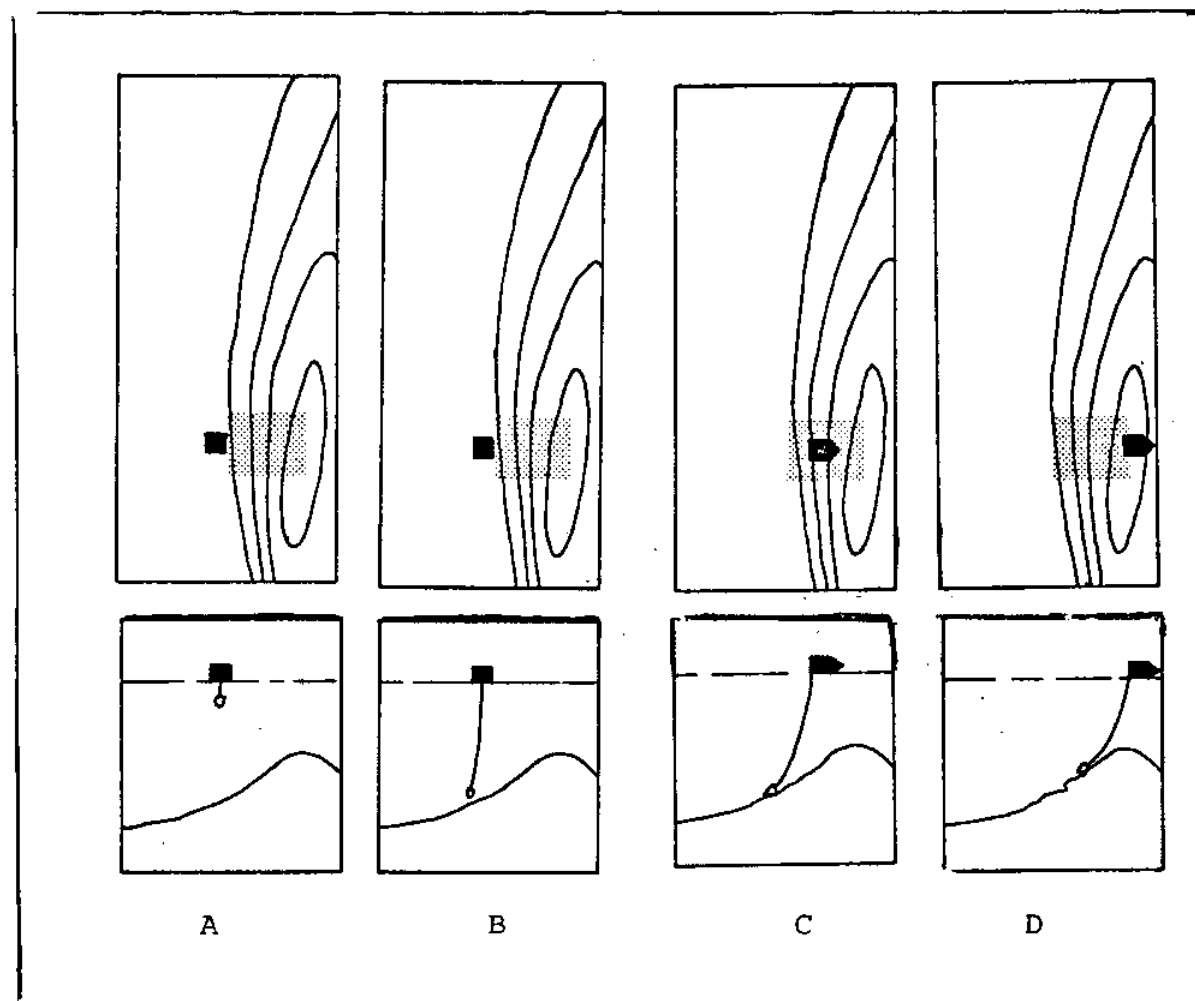


FIGURE 2: One Method of "Power Dredging"

intended point of initial dredge contact. As the ship "hovers", the dredge - with or without a pinger placed on the line above it - is lowered to near the bottom (Fig. 2: A and B). With the dredge about 100 meters above the seafloor (estimated by wire out or by monitoring the pinger returns), the ship starts moving slowly in the direction intended for the sampling profile. With the ship underway, the rate of paying out wire is reduced to lower the dredge gently onto the seafloor and to leave it there, not moving, as the ship slowly steams ahead and the wire stays somewhat slack, but suspended (Fig. 2: C).

When the vessel is above the opposite edge of the target area (usually the shoal end of the sampling profile), it slows again to use only the power and rudder necessary to maintain position; the winch is stopped, and is then reversed to retrieve wire at 5 to 15 m/min. (Fig. 2: D). The ship continues to "hover", the dredge is hauled along, collecting rocks, and this slow retrieval rate is continued until the dredge is lifted off the bottom. Lift-off can be attested to by a tension build-up that is followed by a sudden drop in tension, continuing then at low level, by figuring wire out vs. probable depth, or by monitoring the pinger returns.

WIRE TENSION

The safe working limit and even the breaking strength of the wire rope used in most dredging operations is less than the tension that may be imposed by hang-ups or fouling of the dredge on extremely tenacious rock. They may also be considerably less than the pulling power of the winch. Hence, it may be prudent to install in the dredge assembly a "weak link" that will fail at stresses less than those that will damage or part the wire. If rupture can be made to occur at the dredge, the wire (and pinger clamped alongside it) and perhaps the dredge itself - with its load of rocks - can be saved.

As an example, using a wire with a breaking load of 32,000 pounds and a safe working limit of 25,000 pounds, one can expect to encounter and handle routinely tensions of 16,000 to 20,000 pounds (as read on the tensiometer) if these are imposed slowly. The chain assembly can be designed

to fail at a controlled point, one side of the dredge bridle, with a load of 19,000 - 20,000 pounds. The "chain" then can be made up as follows: a wire rope terminating in an eye or fitting; one shackle; a swivel (then, if weight is used, followed by shackle, weight, and shackle); two shackles; and finally two lengths of chain making the bridle, each connected to the dredge frame by a shackle. The dredge when empty weighs about 300 pounds; when full, perhaps 2000.

The shackles used in this chain assembly are of the 1/2 inch size. To make a weak link, one of the two connecting the bridle to the dredge frame may be replaced with a 3/8 inch shackle. The breaking load of the 3/8 inch shackle is about 8000 pounds, or 6000 pounds more than the weight of a full dredge. Such a breaking limit is appropriate at the weak link because: (a) it is much greater than the weight of the loaded dredge; (b) it is less than the breaking load of the bridle chain (about 9800 pounds) or the 1/2 inch shackles used (16,000 pounds). The shackles 8000 pound limit plus the weight of the wire when dredging at depths of 4500 meters, approximately 9000 pounds, totals 17,000 pounds and thus does not exceed the 25,000 pound safe working limit of the wire. Consequently, if the wire experiences a tension in the range of 17,000 - 19,000 pounds (as read on the tensiometer), failure can occur at the controlled point. With such a failure, the dredge breaks free and hopefully is retrieved undumped - hanging by one bridle chain.

HOOK-UPS

By its very nature, dredging involves a collecting box, or dredge that encounters and hopefully overcomes and collects a specimen of consolidated material. On occasion this specimen may resist these efforts, to the extent that the dredge is hung-up, anchored or snagged so that pulls approaching the safe working limit of the wire are unavailing to free it. This possibility should be considered in advance of the station in discussions with the winch operator and the engine department. When a hang-up has occurred, the winch operator chooses his actions to keep tensions below the wire's working limit and, hopefully, less than the rupture point for the "weak link". The ship's propulsion is stopped or adjusted to keep stresses low and the dredge wire clear of

the propellers. Meanwhile the laboratory and ship's control select a course of action - dependent on depth, slope, drift and other factors - that customarily brings the ship over the point of snagging, just as an anchor might be recovered.

While monitoring the tensiometer, retrieval is begun very slowly, perhaps at about 10 m/min. If the ship's drift has been upslope, this will haul the ship backward. Depths read on the echo-sounder will increase, and little additional increase in tension will occur until the ship is nearly over the snagged dredge. At that time continued retrieval tends to pull the stern under and the ship's heave will cause extreme increases in tension. If prior drift has been downslope, slack will form in the line once the propulsion is stopped and the ship will start falling back over the wire unless retrieval speed is increased. In this case, it may be well to bring the ship about, heading it down drift, keeping the wire clear of the propellers, and paying-out wire as needed to keep tension low while making the turn. Then slow retrieval is continued.

When continued retrieval causes a steady increase in tension, the wire is near vertical. Here, if tension is high but safe, the winch can be stopped and the ship's movements will often free the dredge after a few minutes. If this proves futile, the ship can be moved slowly beyond the dredge into deeper water, so that continued hauling - by engines or winch - will pull the dredge more or less normal to the slope. Again the laboratory and winch operator work together closely, quietly fishing to free the dredge. Steaming in circles or stopping and starting, though dramatic, is of dubious value when a dredge is hung-up in a rough terrain of jointed volcanic boulders. As a last resort, the weak link can be broken by allowing tension to accumulate to the level necessary to break the lightest shackle, so that the dredge will be held by one side of the bridle only. Should this second shackle, or any just above it, fail, the wire and pinger will be spared.

In any case, if a sudden drop in tension occurs, thus signaling either freeing or loss of the dredge, retrieval rate should be increased to keep the pinger from settling to the bottom. Such is extremely unlikely, though, unless the wire has parted between the pinger and the ship. More likely, the dredge will either pull off cleanly or will be hauled routinely so the whole line stays fairly taut. If the laboratory is not yet satisfied with the haul, the dredging procedure may be repeated.

EQUIPMENT

The Chain-Bag Dredge:

The chain-bag dredge used at Scripps Institution of Oceanography consists of a rectangular steel frame (see Fig. 3 and Working Drawing A in the Appendix) to which thirty-two 6 foot lengths of 1/4 inch galvanized steel chain are attached by shackles. The lengths of chain are interconnected with 1/4 inch lap-links to form a chain sleeve. Much of this work and that of tying the interior lines in place can be done conveniently by having the dredge frame suspended by its bridle from a chain hoist or crane.

The inner lines (Fig. 3) is made up of nylon "shrimp netting" (#48, 1 3/4 inch mesh) obtainable in bolts 6 ft. wide. An 8 ft. length of netting is folded lengthwise to 8 ft. x 3 ft. The 8 ft. selvages are sewn together to form a sleeve eight feet long. The sleeve is inserted into the chain bag and the end of the netting that is nearest the dredge frame is tied uniformly to each of the 1/4 inch shackles which suspend the lengths of the chain. For the upper four feet of its length, the mesh liner is tied to the chain bag with marlin every few inches - to keep it from turning inside-out on lowering and from floating out of the bag. The lower part, which is not tied in place, can therefore be turned inside-out to empty it completely of small rocks lodged in the bottom or purse. The lower end of the netting is gathered and tied securely, or laced.

The lower end of the chain sleeve is pursed together using 1/4 inch stainless steel wire. This serves as a rear outlet for the sample if emptying the dredge through the frame end would be hazardous or inconvenient, as might occur when a large boulder is lodged across the dredge's mouth. Ordinarily, however, the dredge is dumped by hooking a hoist to the bottom of the chain bag and up-ending it on a cleared part of the deck.

The Pipe Dredge:

The large pipe dredge is a length of metal pipe screened at the after end either by a metal plate with holes drilled in it, by expanded metal, or by concrete reinforcing rods that form a mesh pattern. The screen is usually welded into place. The spacing of the rods or the size of the

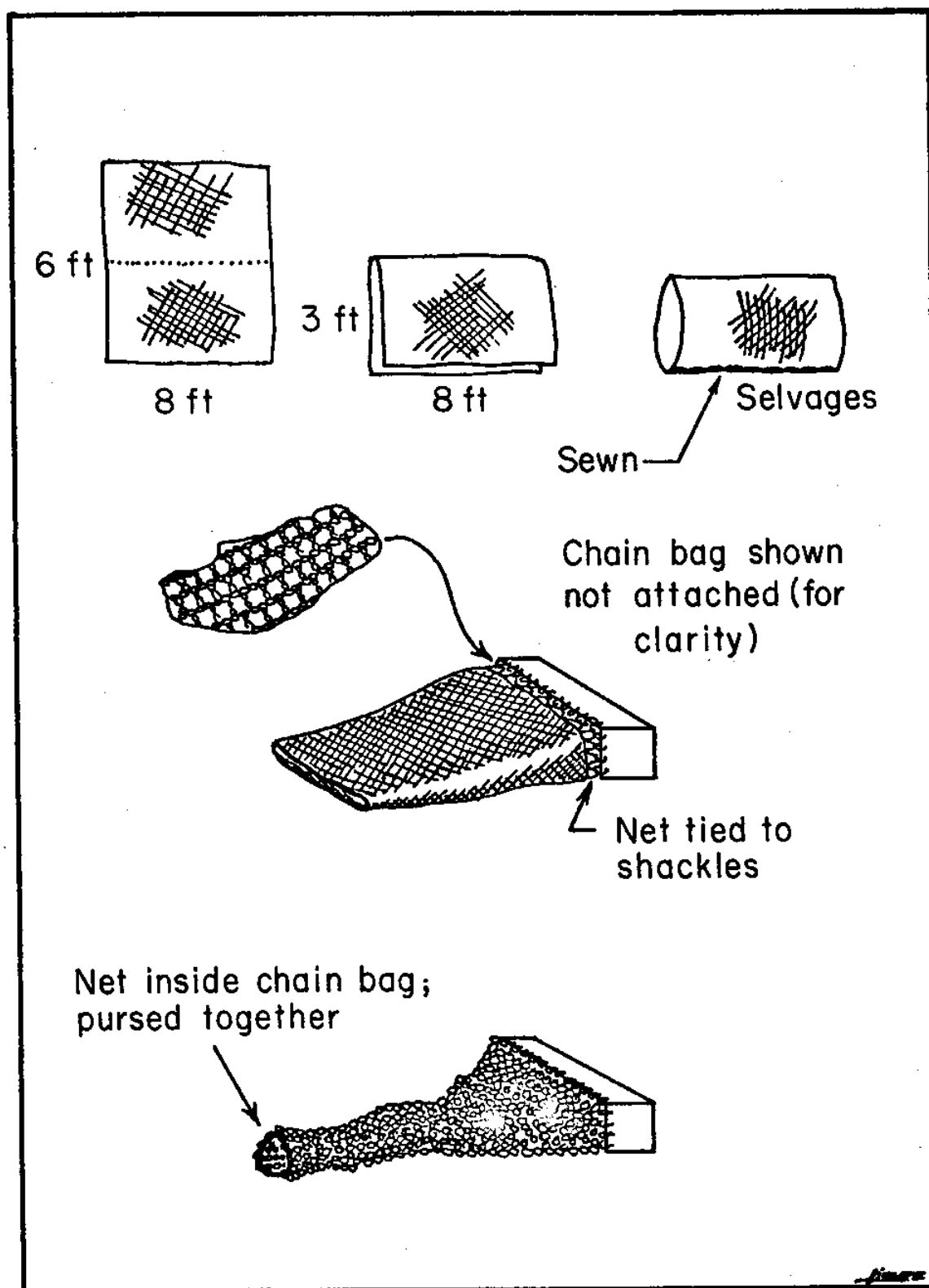


FIGURE 3: Mesh Liner for Chain-Bag Dredge

holes in the metal plate will vary according to the size fragments to be recovered. The fore-rigging and attachment to the wire rope is the same as with the chain dredge.

The small pipe dredge, only rarely used as an appendage to the chain-bag dredge, is a six-to-eight inch piece of pipe, such as scrap piston core barrel, closed at the after end by a canvas specimen bag. It collects sand, coralling debris, or fine sediment that may be present in generally rocky areas.

The Lead Weight:

A lead weight, 150 lbs., an optional piece of ballast placed between the swivel and the dredge bridle chains, serves to keep the dredge's mouth close to the seafloor. It is a length of small diameter pipe fitted with molded lead (see Working Drawing B in the Appendix). Approximately 3 feet of 1/2 inch chain runs through the pipe. A 1/2 inch shackle is attached to each end of the chain, to connect the swivel to the dredge chain.

The Sonar Pinger:

The pinger unit commonly used at Scripps in dredging operations is the E.G. & G. Sonar Pinger Model 220, on a frame designed to facilitate its handling and attachment alongside the wire rope. The pinger frame is connected by 3/8 inch chain to the pinger clamps which hold the assembly to the wire rope. Working drawings for the pinger frame and clamps are included in the corresponding manual of this series on the sonar pinger (IMR TR-21, Sea Grant Publication No. 13, 1971). Be sure the pinger has clamps that fit the size of the wire rope being used.

Wire Rope Fittings:

The terminal end of the wire rope is either looped about a thimble secured with Nico-press fittings, or it is attached to an eye assembly available commercially. For example, for 9/16 inch three-strand wire Scripps has used Electroline's #GD 262X, obtainable without plugs. The plugs, ordered separately to fit the three-strand wire, are three-fluted plugs, #MZ 1450.

The Swivel:

The swivel used on its research vessels is manufactured at Scripps Institution of Oceanography, using commercially available roller bearings (see Working Drawing C in the Appendix). Few commercial swivels are suited to the Scripps service, and those that are appropriate are very expensive. To insure long usage, periodic maintenance of the swivel at sea is highly recommended.

Storage Bags:

After preliminary examination and sorting, and selection of small samples to be brought back for early study, the bulk of the dredged samples are stored aboard ship in seed bags and burlap sacks. For ease of handling, up to 50 lbs. of rocks are placed first in seed bags, with accompanying data cards enclosed, and identifying tags are attached externally to show station type, date and number. The seed bags are then put into burlap sacks, with additional tags attached, and are stored in a dry place until they are off-loaded.

Easily crumbled, friable masses of semi-lithified sediments are packed into wide-mouthed sheet metal cans (commonly called "liver cans") to protect structures such as crusts and worm borings from abrasion.

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APPENDIX I

LOWERING NOTES: INTRODUCTION

Typed copies, verbatim, of the log sheets by R. L. Fisher for three actual lowerings in which an E.G. & G. pinger was used, but under very different spacing, maneuvering, structural setting, weather and depth conditions follow.

CASE A

A very simple 1969 QUEBRADA station at moderate depth on the central portion of the East Pacific Rise. Here wind, sea, and swell came from about the same direction and remained rather constant throughout the operation (see table below). WASHINGTON was positioned updrift of the intended site; the ship drifted throughout and latitude-longitude was computed from observations just before and after the operation.

Note: A large lead weight was clamped on the wire between pinger and dredge. The dredge bridle was connected to the cable directly through a swivel.

Table - Case A

<u>Time</u>		<u>Wind</u>		<u>Sea</u>		<u>Swell</u>	
<u>Local</u>	<u>GMT</u>	<u>Dir.</u>	<u>Force</u>	<u>Dir.</u>	<u>State</u>	<u>Dir.</u>	<u>Ht.</u>
1800 (13)	0000 (14)	075°	16 mph	075°	Mod.	080°	8 ft.
2000 (13)	0200 (14)	070°	10	070°	Mod.	080°	6
2200 (13)	0400 (14)	070°	12	070°	Mod.	080°	6
2400 (13)	0600 (14)	060°	12	060°	Mod.	080°	6

CASE B

A more complex late 1970 ANTIPODE station in a transform fault on the Central Indian Ridge. Here the lower southern flank of a deep steep-walled, slightly sedimented cleft trending about 065°T was to be dredged. In this instance, wind, sea, and swell were from about the same direction, but almost on the ship's port bow. Hence, the engines were used throughout the time the dredge was being lowered and on the bottom; they were secured only during the short recovery. Furthermore, there was one false start on this station, when the winch gave trouble. There was good positioning throughout this lowering from satellite fixes.

Note: On this lowering, the lead weight was shackled immediately ahead of the dredge bridle, just below the swivel.

Table - Case B

<u>Time</u>		<u>Wind</u>		<u>Sea</u>		<u>Swell</u>	
<u>Local</u>	<u>GMT</u>	<u>Dir.</u>	<u>Force</u>	<u>Dir.</u>	<u>State</u>	<u>Dir.</u>	<u>Ht.</u>
1000 (8)	0600 (8)	110°	15 mph	110°	Mod.	115°	8 ft.
1200	0800	115°	14	115°	Mod.	115°	8
1400	1000	110°	14	115°	Mod.	115°	8
1600	1200	110°	15	110°	Mod.	115°	8
1800	1400	120°	15	120°	Mod.	115°	9

CASE C

An extremely deep (>>9100 m) station on the lower portion of the west wall of Tonga Trench, which here trends about N 20° E and has a slightly sedimented bottom at 5120-5125 fms (PDS) or 9890-9900 m (corr.).

Note: In all of these logs, an underlined sounding indicates a strongly reflecting sediment flat, not merely a strong return. During this long lowering, wind and sea were light and from the southeast while a rather long swell came from the southwest (see table). During most of the dredge's trip to the bottom, the ship drifted to establish direction of motion. With the dredge near the bottom, positioning the ship by using the engines and positioning the dredge to encounter the flank at the proper distance above the sedimented flat were critical. Note that the dredge-pinger spacing is rather greater in this deep lowering and steep-walled feature, that again a weight was clamped onto the cable between pinger and dredge, and that a swivel was placed just above the dredge bridle.

Table - Case C

<u>Time</u>		<u>Wind</u>		<u>Sea</u>		<u>Swell</u>	
<u>Local</u>	<u>GMT</u>	<u>Dir.</u>	<u>Force</u>	<u>Dir.</u>	<u>State</u>	<u>Dir.</u>	<u>Ht.</u>
2200 (5)	0900 (6)	Light	airs		Calm	200°	6 ft.
2400	1100	Light	airs		Calm	200°	6
0200 (6)	1300	150°	11 mph	150°	Slt.	220°	6
0400	1500	140°	10	140°	Slt.	220°	6
0600	1700	120°	10	120°	Slt.	220°	6
0800	1900	100°	10	100°	Slt.	220°	6
1000	2100	100°	10	100°	Slt.	220°	6

CRUISE: QUEBRADA

Latitude: 12°23.0'N to 12°23.5'N

DATE: 14 December 1969

Longitude: 103°52.0'W 103°52.6'W

SHIP: Thomas WashingtonDepth of haul: 1440-1405 fms (uncorr.)
2680-2615 m (corr.)

TIME	Depth: GDR	Depth: Corr. M.	WIRE OUT	TENSION	
0145	1462				Stopped on stn. QBR-24-D
0146					Dredge overside. Weight 285 m and pinger 370 m above dredge.
0148	1470, 1475				
0154	1460, 1468				(Note: Stn. on central, newest(?))
0200	1457, 1460				portion of East Pacific Rise.)
0212	1442				
0224	1431				
0230	1426			2500±	
0236	1423		2770	2550	Dredge on bottom; Pinger 180 fm above bottom.
0248	1422, 1445			3000±	
0252.5			3056		Stopped winch. Pinger 15 fm above bottom.
0253.5			3056		Haul in very slowly
0254	1423, 1440				
0255			3046	2500+	Stop winch. Pinger 23 fm above bottom.
0300	1426, 1440				
0308	1412			7500	Single upswing to 7500 lbs.
0311				5000→2	Working. Heading 305°T
0312	1408, 1430				Pinger 58-80 fm above bottom.
0315			3046	3-4000	
0316				5000→1500	
0318	1407, 1423				
0323					Pinger 60 fm above bottom.

CRUISE: QUEBRADA

Latitude:

DATE: 14 Dec, 1969

Longitude:

SHIP: Thomas Washington

Depth of haul:

TIME	Depth: GDR	Depth: Corr. M.	WIRE OUT	TENSION	
0324	1405, 1420			3-5000	Working
0326			3046	5000 +	Haul in at 10 m/min.
0327				4-5000	Working
0328				5-7500	
0330	1405, 1414			5-7000	Steady. Pinger 90 fms. above bottom.
0331.30	1405, 1414		2995	9000-2	
0332				5-7500	Working
0334				3-6000	Working
0336	1405, 1418			5000 → 1	Pinger 130 fms. off bottom.
0336.5			2948	7 → 1	
0338				5000 +	Steady.
0338.5			2934	7.5 → 4	Heading 285° T.
0339.5			2925	7.5 → 1.5	Pinger 130 fms. off bottom.
0340				2500 +	
0342	1408, 1418				
0343					Pinger 120 fms. above bottom.
0344					Working
0345				6.5 → 7.5	Steady
0345+			2874	7.5 → 2	Pinger 135 fms. off bottom.
0346.15			2864	7.5 → 3	
0347.5					Working
0348	1407, 1418				Pinger erratic.
0349					Working
0350					Pinger 160 fms. above bottom.

CRUISE : ANTIPODE

Latitude: 16°38.2'S 16°38;7'S

DATE: 8 November 1970

Longitude: 67°29.7'E to 67°30.6'E

SHIP: R/V MelvilleDepth of haul: 2150 - 1950 fms (PDR)
4035 - 3655 meters (corr.)

TIME	Depth: GDR	Depth: Corr. M.	WIRE OUT	TENSION	
					Intend to dredge base of south scarp on east extension of Marie Celeste Fracture Zone (near 67°30'E) at depth of 2100-1900 fms.
0645Z					o/c 110° at 1 kt.
0655	2120			000	Dredge in water
0656					Sat. fix 0656Z FAIR 16°37.5'S 67°28.9'E
0700	2117, 2202				Level-wind wire problem; half-hitch on intermediate drum.
0705	2115, 2204				
0710	2115, 2205				o/c 110°T at 1+ kt.
0715	2118, 2206				
0720					
0725					Dredge back on deck.
0730	2123, 2208				
0740	2120, 2209				
0750	2120, 2138, 2211				
0800	2119, 2134, 2212				
0830	2115, 2134, 2221				Coming about to 000° @ 1-2
0834					s/o 000°
0840	2070, 2079, 2119				
0845					Coming about to 140°; change speed to 2 kts.
0845.5					Steady on 140°T
0850	2066, 2108, 2155				

DREDGE STATION..... ANTIPODE 6-95-D Page: 2

CRUISE: ANTIPODE

Latitude:

DATE: 8 November 1970

Longitude:

SHIP: R/V Melville

Depth of haul:

TIME	Depth: GDR	Depth: Corr. M.	WIRE OUT	TENSION	
0858					c/c to 110°T; c/s to 1 kt.
0900					
0903				0000	Dredge in water
0905	2130, 2205				
0910	2114, 2130, 2204		269 m.		Winch stopped to put on "D" pinger, "B" transducer, S-863 battery.
0915	2115, 2130, 2204				
0917			269		Pinger in water
0920	2119, 2190, 2131, 2216				
0925	2118, 2133, 2192, 2224				
0926					Stopped winch momentarily
0930	2139, 2194, 2226		1023	2000- 4000	
0945	2152, 2205, 2221, 2365		1976	5000- 6000	
0950	2163, 2222				
0952			2452	8000- 5000	
0955	2178, 2224		2648	6000- 6500	
0959			2849	6000- 8500	Winch stopped momentarily
1000	2223, 2319		2866	6000- 7500	Sat. Fix 1000Z GOOD 16°38.0'S, 167°29.0'E
1005	2224		3088	6-7000	Ship over deep. Winch stopped momentarily.
1007			3209	9000-6000	
1008.5			3339	9200-65	
1010	2224, 2280, 2328		3439	9000	
1015	2226, 2316		3728	8-10,000	

DREDGE STATION.....ANTP-6-95D

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CRUISE : ANTIPODE

Latitude:

DATE: 8 November 1970

Longitude:

SHIP: R/V Melville

Depth of haul:

<i>TIME</i>	<i>Depth: GDR</i>	<i>Depth: Corr. M.</i>	<i>WIRE OUT</i>	<i>TENSION</i>	
1016			3761		Stopped winch
1016.5					Pay out
1017					Slow winch to 40 m/min.
1020	2224, 2318		3917	8-10,200	Sat. Fix 1020Z FAIR 16°38.1'S, 167°29.5'E
1025	2224		4076	8-10,300	
1030	1950, 2221, 2312		4208	9000	Stopped winch
1035	1812, 1930, 2220		4208	8-12,000	Dredge at about 2160 fms below sea level and 50-55 fms above flat 2210-2215 fm sediment surface; separation 202 fms.
1040	1906, 2226		4208		
1045	1848, 1868		4208	8-12,000	Still o/c 110°T ~ 1 kt.
1050	1825, 1847		4208	9-10,000	
1055	1772, 1838		4208	11,000-8,000	
1057			4208	9000 ±	Tensiometer steady.
1100	1764		4208	9000 ±	
1105	1740		4208	9000 ±	
1110	1678, 1720		4208	8-10,000	
1113			4208		Pay out @ 20m/min.; separation 170 fms.
1115	1604, 1652, 1700		4236	8-11,000	
1118			(2280 PDR fms) 4282		DREDGE ON BOTTOM; 138 fms separation
1120	1592, 1639, 1692		4319	9-11,000	Separation 100 fms
1122			4366	8-14,000	

CRUISE: SEVEN TOW

Latitude: 20°28.2'S to 20°28.2'S

DATE: 6 May 1970

Longitude: 173°17.5'W to 173°17.7'W

SHIP: Thomas Washington

Depth of haul: 9650-9135 m

TIME	Depth: GDR	Depth: Corr. M.	WIRE OUT	TENSION	
					On stn. 58-D.
0918	4977, 5124				Heading 300°T,
					to sample base
0924	4978, 5122				of west wall.
					Drifting. Dredge
					overside. Weight
					placed 275 m,
					pinger 455 m
					above dredge.
0936	4990, 5122				
0946	4990, 5122				Sat. Fix 0946
					"Fair"
					20°30.5'S,
					173°16.1'W
0948	4980, 5121				
1000	?, 5121				
1012	?, 5120				Heading 250°T
1024	?, 5120				
1031					PDR off.
1047	4980, 5120				PDR on.
1049					PDR off.
					Apron begins.
1058					PDR on
1100	?, 5116, 5119				
1112	?, 5115, 5119				
1124	?, 5114, 5118				Heading 000°T
1127.5			9606		Stopped winch.
					Pinger 355 fms
					above 5119 fm
					bottom, is about
					4765 fm below sea
					level. Dredge is
					~ 245 fm below
					pinger or 5010 fm
					below sea level

CRUISE: SEVEN TOW

Latitude:

DATE: 6 May 1970

Longitude:

SHIP: Thomas Washington

Depth of haul:

TIME	Depth: GDR	Depth: Corr. M.	WIRE OUT	TENSION	
1134					Sat. Fix. 1134Z "Fair"
					20°30.1'S, 173°16.4'W
1139	.?., 5114,	5119		(with roll) 11.0-15.0	
1140				~13.0	Pay out slow to 9625 meters
1141.5			9625	~13.0	Stop winch. Dredge at 5020fms
1147			9625	~12.5	Heating 000°T
1148				~12.5-13.0	
1200	.?., 5114,	5117			
1201				12.5+	Separation 340 fm (from trench floor)
1215	.?., 5114,	5120			Discrete echoes
1224	.?., 5115,	5120			Heading 000°T
1242	.?., 5113,	5126			
1251					Heading 355°T
1300	.?., 5113,	5126			
1315	.?., 5111,	5119			
1321			9625	13.0	Getting u/w, coming to 250°T, 2.5 Kt.
1330	.?., 5110,	5122		12.5-13.0	Dredge and pinger rising
1337.5			9625		Pay out to bring dredge down to 5020 fm.
1339.5			9680		Stop winch.
1345	.?., 5111,	5127	9680	12.5-13.0	
1352					Sat. Fix. 1352Z "Fair"
					20°29.0'S, 173°16.4'W
1400	5096, 5127		9680	12.5-13.0	

CRUISE: SEVEN TOW

Latitude:

DATE: 6 May 1970

Longitude:

SHIP: Thomas Washington

Depth of haul:

TIME	Depth: GDR	Depth: Corr. M.	WIRE OUT	TENSION	
1406					
1418	5097, 5124				Heading $\approx 345^\circ T$
1439	5100, .?.				
1440					c/s to 4 Kts., to come to $240^\circ T$
1441.5			9681	13.0+	Pay out at 25 m/min. Heading $330^\circ T$
1446			9795		Slow to 15 m/min.
1447			9807		Stop winch.
1454	5117, 5158				c/s to 7 Kts. to come to $240^\circ T$.
1457					Heading $240^\circ T$; c/s to 2.5 Kts.
1458					c/s to 3.5 Kts.
1500					c/s to 4 Kts. on heading $240^\circ T$
1501			9809	13.0	Pay out 20 m/min.
1506			9888	12.5	Stop winch.
1509	.?., 5160?				
1517			9884		Dredge at 5075 fms. Heading $240^\circ T$ at 4 Kts.
1524	4730?, 5130, 5160?				
1525				12.5-13.5	
1527					Dredge at 5070 fms.
1530	4700, 4710				c/s to 5.5 Kts.
1531			9884		Pay out at 5 m/min.
1535					Dredge at 5055 fms.

CRUISE: SEVEN TOW

Latitude:

DATE: 6 May 1970

Longitude:

SHIP: Thomas Washington

Depth of haul:

TIME	Depth: GDR	Depth: Corr. M.	WIRE OUT	TENSION	
1538					1538Z Sat Fix "Good"
					20°28.2'S, 173°17.2'W
1541	4635, 4648, 4730		9981		Dredge at 5060 fms.
1544			10012		Reduce speed to 4 Kts.
1545	4628, 4634, 4727		10025		Dredge at 5065 fms.
1550				12.5-13.0	Dredge at 5095 fms.
1551			10070		Stop winch.
1556					Dredge at "5100". No; bottom is rising; so is dredge.
1558					Dredge probably about 5050 fms. or somewhat less (\approx 5025?)
1600	4577, 4585, 4710			\approx 13.0	
1606	4555, 4571, 4698				Using 5100 re- flector, get dredge depth of about 5040 fms.
1609	4544, 4563, 4690				
1612			10070		Hdg. 240°, Dredge @4950-5050
1615				13.0	Pay out 25 m/min.
1617				\approx 12.5	Separation: \approx 300 fms. c/s to 4.5 Kt.
1620			10,205	\approx 12.5	Separation: \approx 260 fms.
1622			10,256	12.5-13.0	Separation: 250 fms.
					Sat. Fix. 1614Z "Good"
					20°28.1'S, 173°17.7'W
1624			10,320	12.5-13.5	Dredge on bottom?

CRUISE: SEVEN TOW

Latitude:

DATE: 6 May 1970

Longitude:

SHIP: Thomas Washington

Depth of haul:

TIME	Depth: GDR	Depth: Corr. M.	WIRE OUT	TENSION	
1627	4494, 4504, 4580				
1637			10,644	~12.5-13.5	Separation ~80 fms.
1639					Slow pay out to 5 m/min.
1641					Separation ~50 fms.
1642				~12.5-13.5	
1643			10,719		Stop winch.
1644			10,719	12.5	Haul in 10 m/min. Separation 45 fms.
1646.5			10,700	12.5-14.0	Separation ~60 fms.
1648.5				12.5-13.0	Separation 80 fms.
1650					Reduce speed to 3.5 kts.
1650.5	4430, 4438				
1652			10,640	13.0±	Separation: 88 fms.
1655			10,610	12.5-13.0	Slow to 3+ kts.
1657				13.0±	Change haul-in to 20 m/min.
1658			10,560	12.5-13.0	Slow to 2 kts.
1659			10,550		Separation: Heading 300°
1700	4440, 4450				
1701.5			10,510	13.0-14.0	Slow to 1.5 kts. Separation: 100 fms.
1705.5			10,430		Separation 90 fm. Hdg, 312°T
1707.5			10,403	~13.0	Haul in at 30 m/min.
1708					Stop engines. Separation: 90 fm.
1712	4495				Heading ~320°T
1714				12.5-14.0	Separation ~90 fms.

DREDGE STATION..... 58-D

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CRUISE: SEVEN TOW

Latitude:

DATE: 6 May 1970

Longitude:

SHIP: Thomas Washington

Depth of haul:

TIME	Depth: GDR	Depth: Corr. M.	WIRE OUT	TENSION	
1715					
1720				12.5-15.0	Working
1721			10,031	12.5-14.0	
1723			9962	12.5-13.5	Heading $\approx 310^\circ T$.
1724	4428				1725Z * Stars 20°29.1'S, 173°20.2'W
1730	4500		9768	17.0-13.0	Break off! Slow to 20 m/min.
1733					
1734			9684	18.0-13.0	
1735			9650	19.0-	Holding. Tension $\approx 21,000?$
1736			9639		Pay out slowly at 10 m/min.
1739			9659		Getting u/w, coming to 140°T at 2 kts.
1741			9672	≈ 12.5	Stop winch. Haul in @ 15 m/min.
1741+	4550, 4556				Working. Heading 330°T.
1745					Stop engine.
1748	4560, 4567				
1748.5			9550	14.5-12.5	
1749			9529		
1750.5			9521	16.0	Holding.
1751			9513	17.0-13.0	Break off?
1752			9504	14.5-12.0	Break off? Heading 320°T.
1757			9465	12.5±	Haul in at 10 m/min.
1800	4570, 4692		9429		
1801			9411	12.5-15.5	

CRUISE: SEVEN TOW

Latitude:

DATE: 6 May 1970

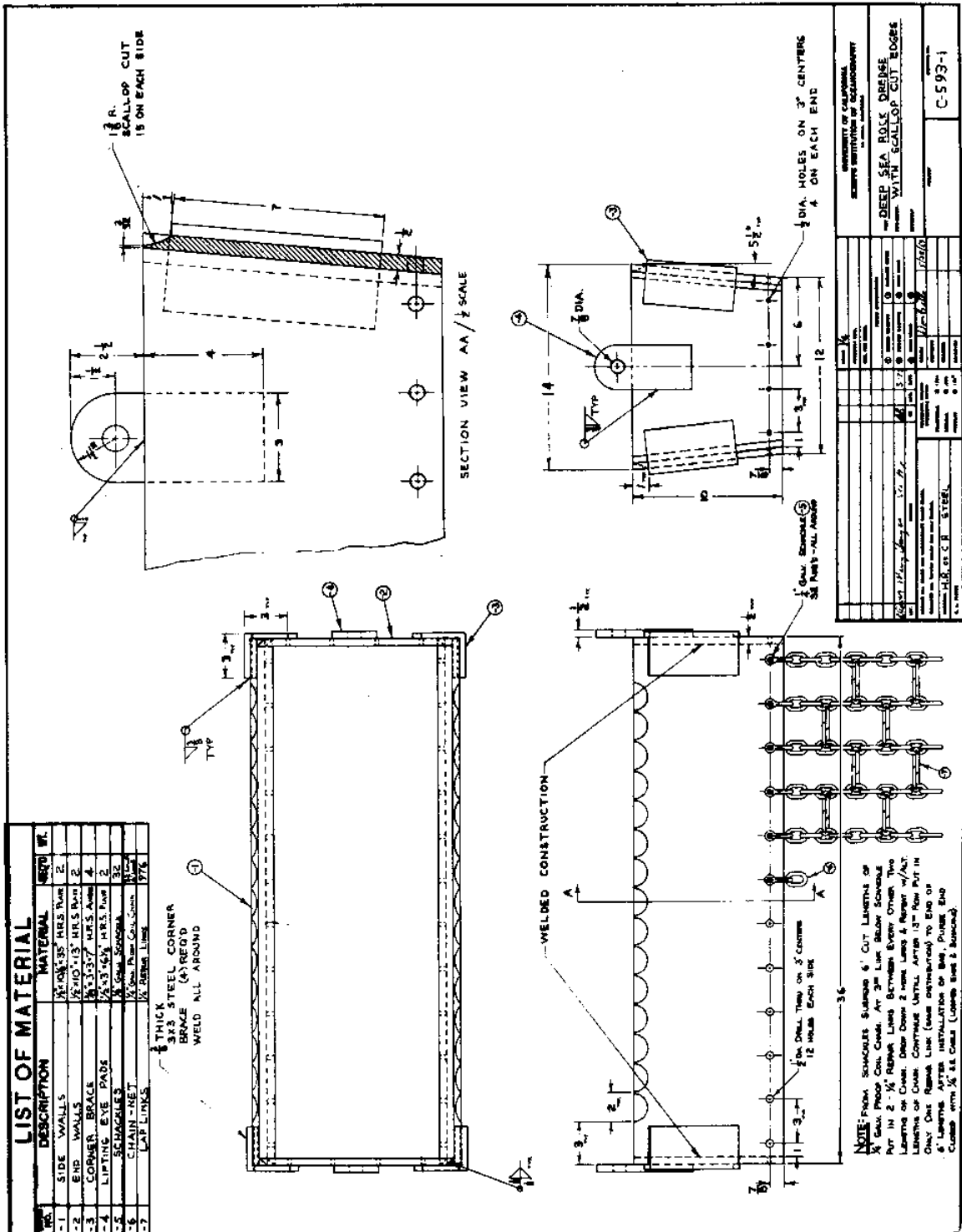
Longitude:

SHIP: Thomas Washington

Depth of haul:

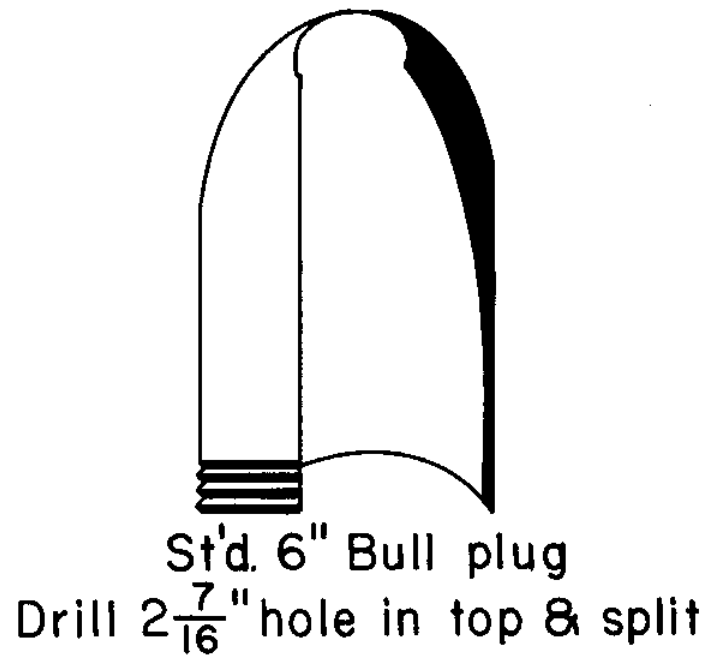
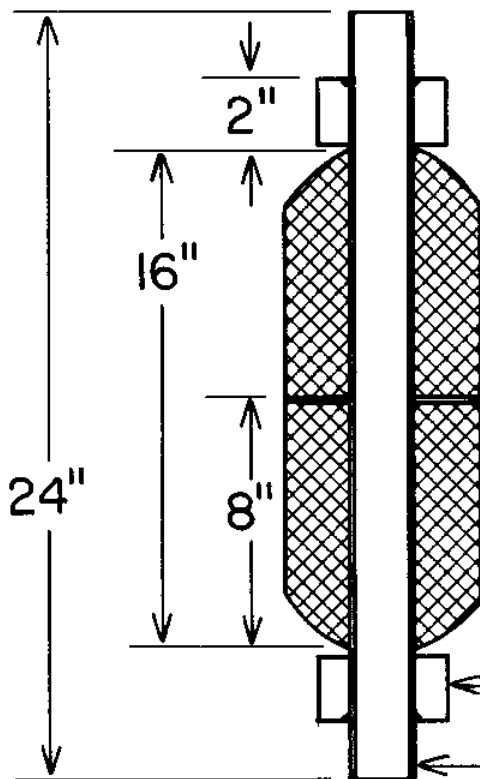
TIME	Depth: GDR	Depth: Corr. M.	WIRE OUT	TENSION	
1802					1802Z Sat Fix. 20°28.2'S; 173°17.7'W
1802.5			9395	15.5→12.0	
1804					
1805			9376	15.5→12.5	
1808.5			9344	~12.5	Working
1809			9330	~14.0-15.0	
1810			9324	15.0→11.0	Break off!
1811			9311	12.5-13.0	Separation: 220 fms.
1812.5			9294	17.0→	
1815			9277	18.0→12.5	Lift off! (See record)
1816			9275		Dredge off bottom
1824			9030		Haul in fast
1830	4594, 4605, 4695				
1848	4600, 4610, 4700				9277 m = 4821 fm. (PDR).
1900	4600, 4710				Believe dredge touched trench wall at depth of 4900- 5050 fm and pulled
1912	4600, 4705				
1924	4597, 4712				off after little horizontal movement
1936	4594, 4716				from about 4700- 4800 fm.
1948	4590-4718				1924Z Sat. Fix. 20°27.8'S, 173°17.6'W
2000	4583				
2012	4579				Heading ~ 000°T
2024	4561				
2036	4540				
2039					Dredge aboard. Suc- cessful. 5 gunny sacks. Gray-green.

APPENDIX II



Working Drawing A: Chain Bag Dredge

LEAD WEIGHT MOLD



Lead Wts. 150 lbs.
Cast in 2-75 lb sections

$\frac{1}{2}$ wall sleeve, weld in place
2" std. galv. pipe

APPENDIX III

TABLE I

Chain and Shackle Characteristics

Source: Myers, J. J., Holm, C. H., and McAllister, R. F., 1969. Handbook of Ocean and Underwater Engineering, New York, McGraw-Hill, 1094 pp.

Galvanized Steel Shackles

<u>Size (Inches)</u>	<u>Working Load (Lbs.)</u>	<u>Shear Load (Lbs.)</u>
3/16	650	3,250
1/4	1,000	5,000
5/16	1,500	7,500
3/8	2,000	10,000
7/16	3,000	15,000
1/2	4,000	20,000
5/8	6,500	32,500
3/4	9,500	47,500

Galvanized Proof-Coil* Steel Chain

<u>Size (Inches)</u>	<u>Working Load** (Lbs.)</u>
3/16	700
1/4	1,175
5/16	1,750
3/8	2,450
7/16	3,250
1/2	4,250
9/16	5,250
5/8	6,375
3/4	9,125

*Also known as "Common Coil".

**proof tested at a proof load equal to at least twice the recommended working load limit.

Shear load is approximately four times the working load.

ABSTRACT

ABSTRACT: It is possible to locate with precision the source of rock samples obtained during deep-sea scientific dredging if adequate precautions are taken in the dredging operation. A pinger on the wire provides an increase in precision over that obtainable without its use.

Dredging is usually carried out up-slope, and may be done either with the ship drifting or underway at slow speed. A weight placed ahead of the dredge helps to insure a proper angle of attack by the dredge bucket. Careful note-keeping is essential for the later determination of the location of the sample with respect to other observations. Sample log forms, a reproduction of the notes on actual lowerings, step-by-step instructions, and plans for typical chain bag- and pipe-dredges are included.